EPA's Composite Model for Leachate Migration with Transformation Products (EPACMTP)

Parameters/Data Background Document

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PARAMETERS/DATA BACKGROUND DOCUMENT

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Office of Solid Waste
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LIST OF SYMBOLS AND ABBREVIATIONS

Symbol	Definition	Section
A_r	anisotropy ratio = K_x/K_z	5.3.6
A_w	area of a WMU (m^2)	2.3.1, 2.4.1, 2.5.1, 2.6.1
B	thickness of the saturated zone (m)	5.3.4.3, 6.6
C_d	metal concentration in the dissolved phase at equilibrium (mg/L)	3.3.3.2
C_s	metal concentration in the sorbed phase at equilibrium (mg/L)	3.3.3.2
C_L	leachate concentration (mg/L)	3.2.3
CV	coefficient of variation (%)	5.2.4
C_w	constituent concentration in the waste (mg/kg)	3.2.2
d_{BG}	depth below grade of WMU (m)	2.3.3, 2.4.6, 2.5.3
D_i	molecular diffusion coefficient in free water for species i (m^2/yr)	3.3.1.1
D_{LF}	landfill depth (m)	2.3.2
D_{lin}	liner thickness (m)	2.4.4
D_s	total sediment thickness (m)	2.4.3
D_u	total depth of the unsaturated zone (m)	5.2.1
D^{s*}	effective molecular diffusion coefficient for species of interest (m^2/y)	6.6
DWS	drinking water standard (mg/L)	3.3.1.2
E_a	Arrhenius activation energy (Kcal/mol)	3.3.2.2.3
F_h	volume fraction of the waste in the landfill at time of closure (m^3/m^3)	2.3.4
FeOx	iron hydroxide content (wt % Fe)	3.3.3.2.3
f_{oc}	fractional organic carbon content (dimensionless)	3.3.3.2.6
f_{oc}^{s}	fractional organic carbon content of the aquifer material (dimensionless)	5.3.11
g	gravitational acceleration (m/s^2)	5.3.4.4
$[H^+]$	hydrogen ion concentration (mol/L)	3.3.2.2.1
H_P	SI ponding depth (m)	2.4.2
I	annual infiltration rate through the source (m/y)	4.3.1, 4.3.2, 4.3.3, 4.3.4
ICLR	climate center index	4.2
ID	metal identification number (unitless)	3.3.3.2.1
IGWR	hydrogeologic environment index (unitless)	3.3.3.2.7,5.3.4.2
IGWT	ground-water type - carbonate/non-carbonate (unitless)	3.3.3.2.7
ISTYPE	soil type	5.2.2

Symbol	Definition	Section
IWLOC	R_{rw} (Receptor well) origination method	6.5
I_R	effective recharge rate outside the strip source area (m/y) or recharge rate outside the source area (m/y)	4.4
J	symbol used to denote a for the acid-catalyzed reaction, b for the base-catalyzed reaction and n for the neutral reaction	3.3.2.2.3
K	hydraulic conductivity (m/yr)	5.3.4.4
k_1	nonlinear Freundlich parameter for the unsaturated zone (mg constituent/kg dry soil))	5.2.9
K_a^T	acid-catalyzed hydrolysis rate constant (1/(mol.yr))	3.3.2.2.1
K_a^{Tr}	acid-catalyzed hydrolysis rate constant at reference temperature (1/(mol.yr))	3.3.2.2.3
K_b^T	base-catalyzed hydrolysis rate constant (1/(mol.yr))	3.3.2.2.2
K_b^{Tr}	base-catalyzed hydrolysis rate constant at reference temperature (1/(mol.yr))	3.3.2.2.5
K_d	distribution (solid-aqueous phase) partition coefficient in the unsaturated zone (cm^3/g) (Freundlich Coefficient)	3.3.3, 5.2.8
K_d^s	solid-liquid distribution coefficient of the aquifer (cm^3/g)	5.3.12
K_J^T	hydrolysis rate constant for reaction process J, corrected for the subsurface temperature T (1/(mol.yr) for the acid- and base-catalyzed reactions; 1/yr for the neutral reaction)	3.3.2.2.3
K_J^{Tr}	hydrolysis rate constant for reaction process J, measured at the reference temperature T_r (1/(mol.yr) for the acid- and base-catalyzed reactions; 1/yr for the neutral reaction)	3.3.2.2.3
K_{lin}	saturated hydraulic conductivity of liner (m/y)	2.4.5
K_n^T	neutral hydrolysis rate constant at (1/yr)	3.3.2.2.1
K_n^{Tr}	neutral hydrolysis rate constant at reference temperature (1/yr)	3.3.2.2.3
k_d	soil-water partition coefficient (L/kg)	3.3.2.1
k_{oc}	constituent-specific organic carbon partition coefficient (cm^3/g)	3.3.2.1
k_{ow}	octanol-water partition coefficient (cm^3/g)	3.3.2.1
K_s	saturated hydraulic conductivity (cm/hr)	5.2.3
K_x	hydraulic conductivity in the *x* direction (m/y)	5.3.5
K_y	hydraulic conductivity in the horizontal transverse (y) direction (m/y)	5.3.6
ℓ	daughter species number	3.3.2.3.1
LOM	leachate organic acid concentration (mol/L)	3.3.3.2.4
LYCHK	constraint on well distance from plume centerline	6.5
LZCHK	constraint on depth of intake point below water table	6.6

Symbol	Definition	Section
ℓ	daughter species number	3.3.2.3.1
LN	log normal distribution	5.2.2
M	number of immediate parent species	3.3.2.3.2
m	species number of immediate parent	3.3.2.3.3
MW_ℓ	molecular weight of species ℓ (g/mol.)	3.3.1.3
N	sample size	5.2.4
NO	Normal distribution	5.2.2
$[OH^-]$	hydroxyl ion concentration (mol/L)	3.3.2.2.2
%OM	percent organic matter (dimensionless)	3.3.3.2.5, 5.2.7
PWS	waste volume (m^3)	2.3.5
pH	ground-water pH (standard units)	3.3.3.2.2, 5.2.10, 5.2.13
Q_1^F	background ground-water flux (m^2/y)	6.6
Q_4^F	recharge flux downgradient of the source (m^2/y)	6.6
r	regional hydraulic gradient (m/m)	5.3.4.5
R_g	Universal Gas Constant (1.987E-3 Kcal/deg-mol)	3.3.2.2.3
R_i	retardation factor for species i (dimensionless)	3.3.2.1
R_{rw}	radial distance between waste management unit and well (m)	6.2
R_∞	distance between the center of the source and the nearest downgradient boundary where the boundary location has no perceptible effects on the heads near the source (m)	2.4.8
R^s	retardation coefficient (dimensionless)	5.3.7
SB	log ratio distribution	5.2.2
SD	standard deviation	5.2.4
T_r	hydrolysis reference temperature (℃)	3.3.2.2.6
T	ground-water/subsurface temperature (℃)	3.3.2.2.3, 5.2.12, 5.3.9
t_d	exposure time interval of interest (yr)	6.8
t_p	leaching duration (yr)	2.3.6, 2.4.9, 2.5.2, 2.6.2
V_x	longitudinal ground-water (seepage) velocity (in the x-direction) (m/y)	5.3.5
X	sample mean	5.2.4
x	principal Cartesian coordinate along the regional flow direction (m)	6.4
x_{rw}	distance from the downgradient boundary of the WMU to the receptor well (m)	6.4

Symbol	Definition	Section
x_t	average travel distance in the x direction (m)	5.3.8.1
x_w	length of the WMU in the x-direction (parallel to ground-water flow) (m)	6.6
y	principal Cartesian coordinate normal to the flow direction, or distance from the plume centerline (m)	6.5
y_D	source width along the y-axis (m)	6.5
y_{rw}	Cartesian coordinate of the receptor well in the y-direction (m)	6.5
z	principal Cartesian coordinate in the vertical direction (m)	6.6
z^*_{rw}	z-coordinate of the receptor well positive downward from the water table(m)	6.6
	GREEK SYMBOLS	
α	van Genuchten soil-specific shape parameter (1/cm)	5.2.2, 5.2.4.1
α_L	longitudinal dispersivity of the aquifer (m)	5.3.8.1, 6.6
α_{Lu}	longitudinal dispersivity in the unsaturated zone (m)	5.2.6
α_{Ref}	reference longitudinal dispersivity, as determined from the probabilistic distribution (m)	5.3.8.1
α_T	horizontal transverse dispersivity (m)	5.3.8.2, 6.5
α_V	vertical transverse dispersivity (m)	5.3.8.2, 6.6
β	van Genuchten soil-specific shape parameter (dimensionless)	5.2.2, 5.2.4.2
γ	van Genuchten soil-specific shape parameter (dimensionless) = $1 - 1/\beta$	5.2.4
η	species-specific nonlinear Freundlich exponent for the unsaturated zone	5.2.9
η^s	Freundlich exponent for the saturated zone (dimensionless)	5.3.13
θ	soil water content (dimensionless)	3.3.2.1
θ_r	residual soil water content (dimensionless)	5.2.4.3
θ_{rw}	angle measured counter-clockwise from the plume centerline (degrees)	6.3
θ_s	saturated soil water content (dimensionless)	5.2.4.4
λ	overall first-order hydrolysis transformation rate(1/y)	3.3.2.2
λ_1	hydrolysis constant for dissolved phase (1/y)	3.3.2.2.2
λ_2	hydrolysis constant for sorbed phase (1/y)	3.3.2.2.1
λ_b^s	biodegradation rate in the saturated zone (1/yr)	5.3.15
λ_c^s	chemical degradation rate in the saturated zone (1/yr)	5.3.14
λ_{bu}	transformation coefficient due to biological transformation (1/y)	5.2.11

LIST OF SYMBOLS AND ABBREVIATIONS (continued)

Symbol	Definition	Section
λ_{cu}	transformation coefficient due to chemical transformation (1/y)	5.2.10
μ	dynamic viscosity of water (N-s/m^2)	5.3.4.4
$\xi_{\ell m}$	stoichiometric fraction of parent m that degrades into daughter ℓ/speciation factor (dimensionless)	3.3.2.3.4
ρ	density of water (kg/m^3)	5.3.4.4
ρ_b	bulk density of the aquifer (g/cm^3)	3.3.2.1, 5.3.3
ρ_{bu}	soil bulk density of the unsaturated zone (g/cm^3)	5.2.5
ϕ	porosity/water content in the unsaturated zone (dimensionless)	3.3.2.2, 5.3.2
ϕ_e	effective porosity of the saturated zone (dimensionless)	6.6

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1.0 INTRODUCTION

This document provides background information on the parameters and data sources used in **EPA**'s **C**omposite **M**odel for **L**eachate **M**igration with **T**ransformation **P**roducts (EPACMTP). EPACMTP is a subsurface fate and transport model used by EPA's Office of Solid Waste in the RCRA program to establish regulatory levels for concentrations of constituents in wastes managed in land-based units. This document describes the EPACMTP input parameters, data sources and default parameter values and distributions that EPA has assembled for its use of EPACMTP as a ground-water assessment tool. EPA has also developed a complementary document, the *EPACMTP Technical Background Document* (U.S. EPA, 2003a), which presents the mathematical formulation, assumptions and solution methods underlying the EPACMTP. These two documents together are the primary reference documents for EPACMTP, and are intended to be used together.

The remainder of this section describes how this background document is organized. The parameters and data are documented in six main categories, as follows:

- Section 2 describes the Waste Management Unit (Source) Parameters;
- Section 3 describes the Waste and Constituent Parameters;
- Section 4 describes the Infiltration and Recharge Parameters;
- Section 5 describes the Subsurface Parameters;
- Section 6 describes the Ground-water Well Location Parameters; and
- Section 7 provides a list of References

Several appendices provide complete listings of data distributions for a number of the EPACMTP input parameters.

To facilitate the cross-referencing of information between this document and the *EPACMTP Technical Background Document* (U.S. EPA, 2003a), each section begins with a table that lists the parameters described in that section, and provides, for each parameter, a reference to the equation(s) and/or section number in the *EPACMTP Technical Background Document* (U.S. EPA, 2003a) that describes how each parameter is used in the EPACMTP computer code.

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2.0 WASTE MANAGEMENT UNIT (SOURCE) PARAMETERS

EPACMTP can simulate the subsurface migration of leachate from four different types of waste management units (WMUs). Each of the four unit types reflects waste management practices that are likely to occur at industrial Subtitle D facilities. The WMU can be a landfill, a waste pile, a surface impoundment, or a land application unit. The latter is also sometimes called a land treatment unit. Figure 2.1 presents schematic diagrams of the different types of WMUs modeled in EPACMTP.

Landfill. Landfills (LFs) are facilities for the final disposal of solid waste on land. EPACMTP is typically used to model closed LFs with an earthen cover. LFs may be unlined, or they may have some type of engineered liner, but the model assumes no leachate collection system exists underneath the liner. The LF is filled with waste during the unit's operational life. Upon closure of the LF, the waste is left in place, and a final soil cover is installed. The starting point for the EPACMTP simulation is the time at which the LF is closed, i.e., the unit is at maximum capacity. The release of waste constituents into the soil and ground water underneath the LF is caused by dissolution and leaching of the constituents due to precipitation which percolates through the LF. The type of liner that is present (if any) controls, to a large extent, the amount of leachate that is released over time from the unit. LFs are modeled in EPACMTP as WMUs with a rectangular footprint and a uniform depth. The EPACMTP model does not explicitly account for any loss processes occurring during the unit's active life (for example, due to leaching, volatilization, runoff or erosion, or biochemical degradation), however these processes will be taken into account if the input value for leachate concentration is based on a site-specific chemical analysis of the waste (such as results from a Toxicity Characteristic Leaching Procedure (TCLP) or Synthetic Precipitation Leaching Procedure (SPLP) analysis). The leachate concentration used as a model input is the expected initial leachate concentration when the waste is 'fresh'. Because the LF is closed, the concentration of the waste constituents will diminish with time due to depletion of the landfilled wastes; the model is equipped to simulate this "depleting source" scenario for LFs, but other source options are available, and are explained in Section 2.3.

Surface Impoundment. A surface impoundment (SI) is a WMU which is designed to hold liquid waste or wastes containing free liquid. SIs may be either ground level or below ground level flow-through units. They may be unlined, or they may have some type of engineered liner. Release of leachate is driven by the ponding of water in the impoundment, which creates a hydraulic head gradient across the barrier underneath the unit. The EPACMTP model considers a SI to be a temporary WMU with a finite operational life. At the end of the unit's operational life, we assume there is no further release of waste constituents to the ground water (that is, there is a clean closure of the SI). SIs are modeled as pulse-type sources; leaching occurs at a constant leachate concentration over a fixed period of time equal to the unit's operating life. The EPACMTP model assumes a constant ponding depth (depth of waste water in SI) during the operational life (see Section 2.2.4).

Waste Pile. Waste piles (WPs) are typically used as temporary storage or treatment units for solid wastes. Due to their temporary nature, they are typically not covered. Similar to LFs, WPs may be unlined, or they may have some type of engineered liner. EPACMTP assumes that WPs have a fixed operational life, after which the WP is removed. Thus, WPs are modeled as pulse-type sources; leaching occurs at a constant leachate concentration over a fixed period of time which is equal to the unit's operating life (see Section 2.5.2).

Land Application Unit. Land application units (LAUs) (or land treatment units) are areas of land receiving regular applications of waste that is either tilled directly into the soil or sprayed onto the soil and then tilled. EPACMTP models the leaching of wastes after they have been tilled with soil. EPACMTP does not account for the losses due to volatilization during or after waste application. LAUs are only evaluated for the no-liner scenario because liners are not typically used at this type of facility. EPACMTP assumes that an LAU is a temporary WMU with a fixed operational life, after which the waste is no longer land-applied. Thus, LAUs are modeled in EPACMTP as a constant pulse-type leachate source, with a leaching duration equal to the unit's operational life (see Section 2.6.2).

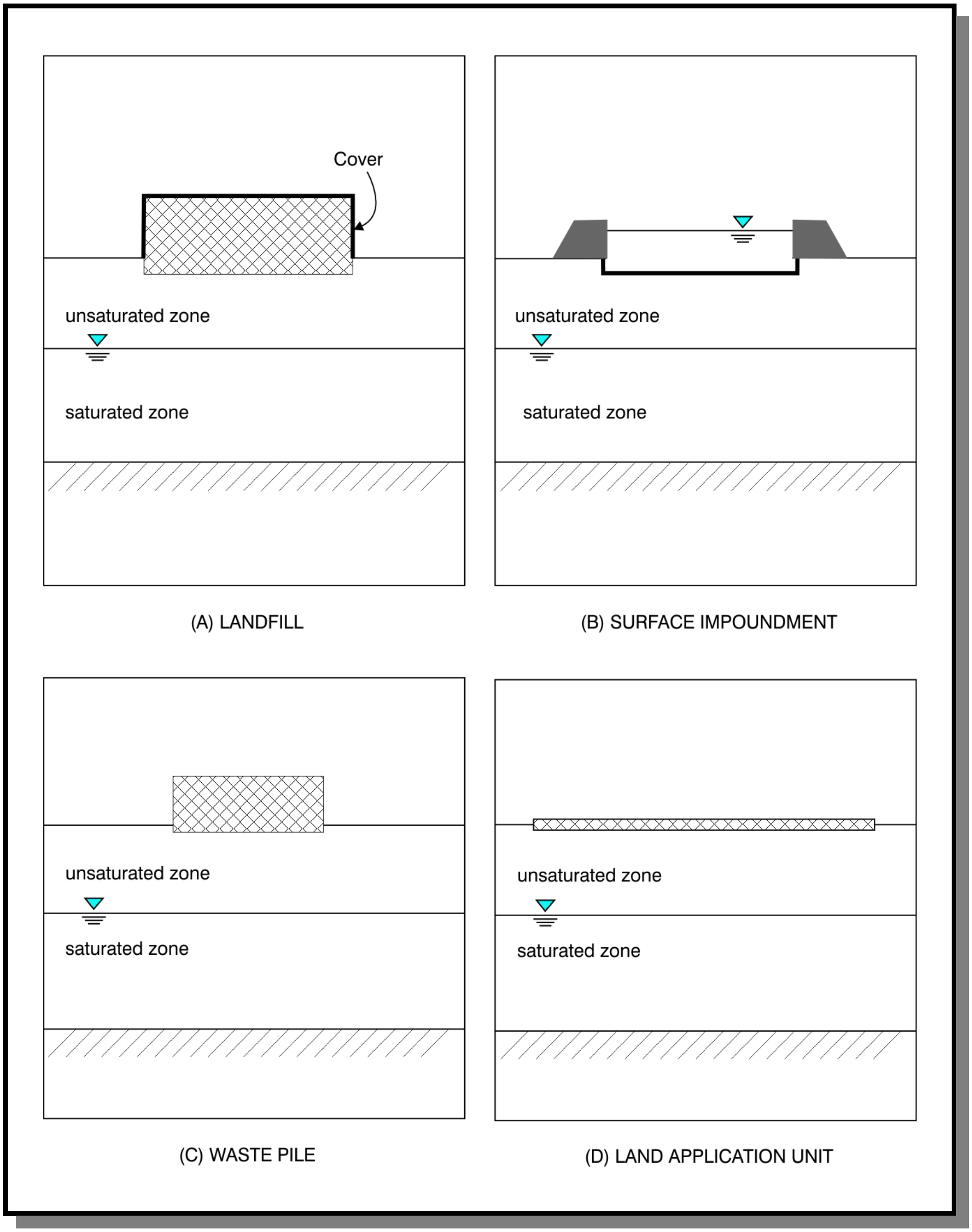

Figure 2.1 WMU Types Modeled in EPACMTP.

2.1 SOURCE PARAMETERS

The input parameters used in EPACMTP to describe the waste management unit are listed below in Table 2.1

Table 2.1 Waste Management Unit (Source) Parameters

WMU Type	Parameter	Symbol	Units	Section	Equation in EPACMTP TBD
LF	Area	A_w	m^2	2.3.1	2.3
	Depth	D_{LF}	m	2.3.2	2.3
	Depth Below Grade	d_{BG}	m	2.3.3	2.2.2.2
	Landfill Waste Fraction (Volume Fraction)	F_h	m^3/m^3	2.3.4	2.5
	Waste Volume	PWS	m^3	2.3.5	
	Leaching Duration	t_p	yr	2.3.6	2.7
SI	Area	A_w	m^2	2.4.1	2.2.2.2
	Ponding Depth	H_P	m	2.4.2	2.17
	Total Sediment Thickness	D_s	m	2.4.3	2.2.2.2
	Liner Thickness	D_{lin}	m	2.4.4	2.24b
	Liner Conductivity	K_{lin}	m/yr	2.4.5	2.24b
	Depth Below Grade	d_{BG}	m	2.4.6	2.24b
	Leak Density	ρ_{leak}	$holes/m^2$	2.4.7	2.24c
	Distance to Nearest Surface Water Body	R_∞	m	2.4.8	2.31
	Operating Life/Leaching Duration	t_p	yr	2.4.9	2.2.2.2
WP	Area	A_w	m^2	2.5.1	2.27
	Operating Life/Leaching Duration	t_p	yr	2.5.2	2.27
	Depth Below Grade	d_{BG}	m	2.5.3	2.2.2.2
LAU	Area	A_w	m^2	2.6.1	2.30
	Operating Life/ Leaching Duration	t_p	yr	2.6.2	2.30

2.2 DATA SOURCES FOR WMU PARAMETERS

Data from two nationwide EPA surveys of non-hazardous (RCRA Subtitle D) industrial facilities were used to develop databases of EPACMTP input values for WMU parameters. Data for LFs, WPs, and LAUs were obtained from an EPA survey of industrial Subtitle D facilities conducted in 1985 (U.S. EPA, 1986, referred to as *"The 1986 Subtitle D Survey"*). The survey provides a statistically representative subset of observations of site specific areas, volumes and locations for industrial Subtitle D facilities in the United States. Data for SIs were obtained from a recent U.S. EPA survey of industrial SIs (U.S. EPA, 2001a, "*Surface Impoundment Study"*). What follows is a general description of the data used from these two studies to compile the databases of WMU input parameters for the EPACMTP model; the actual distributions of values of these WMU input parameters are then summarized in Sections 2.3 - 2.6, and are listed in their entirety in Appendix D.

The WMU locations are shown in Figures 2.2 - 2.5. Information on WMU locations was used to coordinate other WMU-specific data with climate and hydrogeological parameter values. Specifically, we first used the HELP (Schroeder, et. al., 1994) water balance model and climate data from 102 climate stations and three common soil types to develop infiltration and recharge rates for unlined and single-lined WMUs (see Section 4.2 and Appendix A). Then, for each WMU site, we assigned: 1) a climate index corresponding to the nearest, representative climate station (used to select infiltration and recharge rates) (see Section 4.2); 2) a hydrogeologic index according to the regional aquifer type used to generate depth to water and aquifer characteristics (see Sections 5.2 and 5.3); and 3) a soil and aquifer temperature used to calculate hydrolysis transformation rates for organic constituents (see Sections 3.6.2 and 4.3). This allows appropriate site-based climate and hydrogeological parameter values to be generated for each site in the WMU database "on the fly" while the EPACMTP model is running a Monte Carlo analysis.

Landfills

The *1986 Subtitle D Survey* provided LF data consisting of 824 observations of facility locations, area, number of units in the facility, facility design capacity, total remaining facility capacity, and the relative weight of each facility. The relative weight was assigned based on the total number of employees working at the facility and reflects the quantity of the waste managed in that facility. The values of physical characteristics for each WMU were obtained by dividing the facility values by the number of units in the facility.

LF data were screened to eliminate unrealistic observations by placing constraints on the WMU depth and volume . The WMU depth, calculated by dividing the unit capacity by its area, was constrained to be greater than or equal to 2 feet (0.67m), and less than or equal to 33 feet (10m); these limits on unit depth were adopted from a previous analysis used to support the Toxicity Characteristic (TC) Rule (U.S. EPA, 1990). In addition, the LF volume was constrained to be greater than the remaining capacity.

A joint distribution was derived from available unit areas correlated with unit volumes that met the unit depth and remaining capacity constraints. The distribution was assumed to be lognormal. Random samples of this distribution were used in cased where the unit area, the unit volume, or both were missing.

If the WMU depth or remaining capacity constrains were violated, the reported unit volume was replaced with a sample from the joint distribution, based on the reported unit area, based on the assumption that the reported unit area was more likely to be correct.

Figure 2.2 shows the geographic locations of LF WMUs used in developing the EPACMTP database of LF sites. A compete listing of the site-based LF input parameter values is provided in Appendix D.

Figure 2.2 Geographic Locations of Landfill WMUs.

Surface Impoundments

The original EPACMTP database of SI input parameter values (based on the *1986 Subtitle D survey*) was updated with more complete data derived from the results of EPA's recent 5-year study of nonhazardous (Subtitle D) industrial SIs in the United States (U.S. EPA, 2001a). The *Surface Impoundment Study* is the product of a national survey of facilities that operate non-hazardous industrial waste SIs. The updated database is comprised of SI characteristics from 503 SI units located at 143 facilities throughout the United States.

The *Surface Impoundment Study* provided data on impoundment locations, area, operating depths (depth of ponding in the impoundment), depth of the SI base below the ground surface, sludge volume, operational life of the impoundment, closure plans, and proximity of the impoundment to a surface water body.

The current version of the EPACMTP database of SI sites was compiled for analyses included in the U.S. EPA Industrial Waste Management Evaluation Model (U.S. EPA, 2003b). As a result, the database includes assumptions specific to that effort. Specifically, the thickness of sludge at the bottom of SI units was assumed to be 0.2 m for all sites; sites with unknown operating lines and no closure plans were assumed to operate for 50 years; all units were assumed to be built on top of the ground surface; and unknown distances to the nearest surface water body or distances given as >2,000 m were set to 5,000 m.

Figure 2.3 shows the geographic locations of SI WMUs (from the *Surface Impoundment Study*) used in developing the EPACMTP database of SI sites. Due to the scale of this map, the individual units at each facility are not shown. A compete listing of the site-based SI input parameter values is provided in Appendix D.

Figure 2.3 Geographic Locations of Surface Impoundment WMUs.

Waste Piles

The *1986 Subtitle D survey* included 847 WP facilities with data on facility area, number of units, and the total amount of waste placed in the facility (waste volume) in 1985. Unit values were derived by dividing the facility values by the number of units in the facility. No screening constraints were placed on the WP data. The 114 facility areas and the 30 facility waste volumes reporting zero values were set to 0.005 acres (20 m^2) and 0.005 mega-tons (Mton), respectively. These default values were adopted from a previous analysis used to support the Toxicity Characteristic (TC) Rule (U.S. EPA, 1990).

Thirty facilities did not report waste volume. All facilities reported facility area. Missing volume values were replaced by random realizations from the probability distribution of volume conditioned on area. The conditional distribution was assumed to be lognormal and was derived from the non-missing unit area/volume pairs.

Figure 2.4 shows the geographic locations of WP WMUs used in developing the EPACMTP database of WP sites. A compete listing of the site-based WP input parameter values is provided in Appendix D.

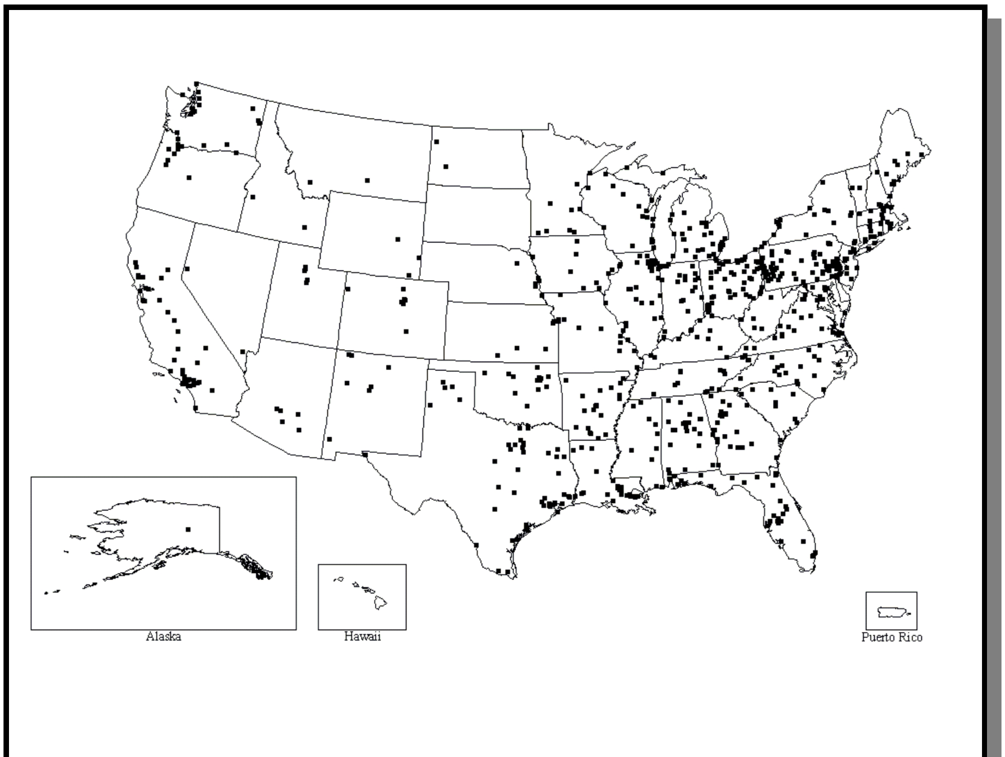

Figure 2.4 Geographic Locations of Waste Pile WMUs.

Land Application Units

The *1986 Subtitle D survey* included 352 LAU facilities, with data on location, area, number of units in each facility, and the total amount of waste managed (waste volume) in 1985. Individual unit values were derived by dividing the facility values by the number of units in the facility. Application rates were derived by dividing the waste managed in 1985 by the site acreage. Unrealistic values were screened from these data by constraining the waste application rates to be less than 10,000 tons/acre/year. This assumes a maximum application rate of 200 dry tons/acre/year with a 2% solids content.

Eight did not report waste volume, and twelve were screened out due to the application rate constraint. Of the 352 facilities, all reported a facility and none were screened. Three reported zero areas and nine reported zero waste volumes were set to 0.005 acres (20 m^2) and 0.005 Mton, respectively.

Missing and screened values were replaced by random realizations from the joint area/volume probability distribution or the corresponding marginal distributions depending on whether both or only one of either the waste volume or area values were missing or screened. The joint distribution was assumed to be lognormal and was derived from the non-missing unit area/volume pairs that met the unit depth constraint.

Figure 2.5 shows the geographic locations of LAU WMUs used in developing the EPACMTP database of LAU sites. A compete listing of the site-based database of LAU input parameter values is provided in Appendix D.

Figure 2.5 Geographic Locations of Land Application Unit WMUs.

2.3 LANDFILLS (LF)

This section discusses the individual WMU-related parameters required to perform a LF analysis using EPACMTP. Most applications of EPACMTP are for national or regional regulatory development purposes, in which case, each of the following LF input parameters is described using a probability distribution. The default distributions are described in the following sections. However, EPACMTP can also be used in a location-waste-specific mode; in this case, each of the following LF input parameters could be assigned a site-specific constant value or a site-specific distribution of values. These site-specific data need to be gathered by the user prior to performing the EPACMTP modeling analysis. However, site-specific implementation of EPACMTP will yield results which may not reflect the site-specific heterogeneities and anisotropic conditions.

The source-specific input parameters for the LF scenario include parameters to determine the amount of waste disposed in the LF and the source leaching duration. Together with the infiltration and recharge rates and the initial waste and leachate concentrations, these parameters are used to determine how much contaminant mass enters the subsurface and over what time period. The source-specific parameters for the LF scenario are individually described in the following sections.

2.3.1 Landfill Area (A_w)

Definition

The LF area is defined as the footprint of the LF. EPACMTP assumes the LF to be rectangular. By default, the length and width of the LF are each calculated as the square root of the area.

Parameter Value or Distribution of Values

The entire distribution is presented in Appendix D. The cumulative frequency distribution of LF area is listed in Table 2.2. For a given percentile (%) frequency and area value pair in this table, the percentile denotes the relative frequency or likelihood of parameter values in the entire distribution being less than or equal to the corresponding parameter value in the right-hand column.

Table 2.2 Cumulative Frequency Distribution of Landfill Area.

%	Area (m^2)
0	4.05E+01
10	4.86E+02
25	2.43E+03
50	1.21E+04
75	5.26E+04
80	6.56E+04
85	9.11E+04
90	1.42E+05
95	2.23E+05
100	3.12E+06

Data Sources

The data for LF area listed in Table 2.2 were obtained from EPA's *1986 Subtitle D Survey* (U.S. EPA, 1985).

Use In EPACMTP

The LF area is used to determine the area over which leachate enters the subsurface. It is also one of several parameters used to calculate the total contaminant mass present in the LF at closure. The total contaminant mass is a necessary input when using the LF depleting source option, since the contaminant is leached to the subsurface until the waste in the LF is depleted (see Section 2.2.1.3.3 of the *EPACMTP Technical Background Document*; U.S. EPA, 2003a).

2.3.2 Landfill Depth (D_{LF})

Definition

The LF depth is defined as the average depth of the LF, from top to bottom; the thickness of the cover soil is assumed to be small compared to the depth. Note that the LF depth is measured from the top to the base of the unit, irrespective of where the ground surface is.

Parameter Value or Distribution of Values

The entire distribution is presented in Appendix D. The cumulative frequency distribution of LF depth is listed in Table 2.3. For a given percentile (%) frequency and value pair in this table, the percentile denotes the relative frequency or likelihood of parameter values in the entire distribution being less than or equal to the corresponding parameter value in the right-hand column.

Table 2.3 Cumulative Frequency Distribution of Landfill Depth.

%	Depth (m)
0	5.10E-01
10	8.80E-01
25	1.32E+00
50	2.57E+00
75	4.09E+00
80	4.53E+00
85	5.20E+00
90	6.13E+00
95	7.12E+00
100	1.01E+01

Data Sources

Data for the nationwide distribution of LF depths was obtained from the *1986 Subtitle D survey* (EPA, 1986).

Use In EPACMTP

The LF depth is one of several parameters used to calculate the contaminant mass within the LF; the contaminant mass is an important input for the LF depleting source option (see Section 2.2.1.3.3 of the *EPACMTP Technical Background Document*; U.S. EPA, 2003a).

2.3.3 Landfill Base Depth below Grade (d_{BG})

Definition

The depth below grade is defined as the depth of the bottom of the LF below the surrounding ground surface, as schematically depicted in Figure 2.6.

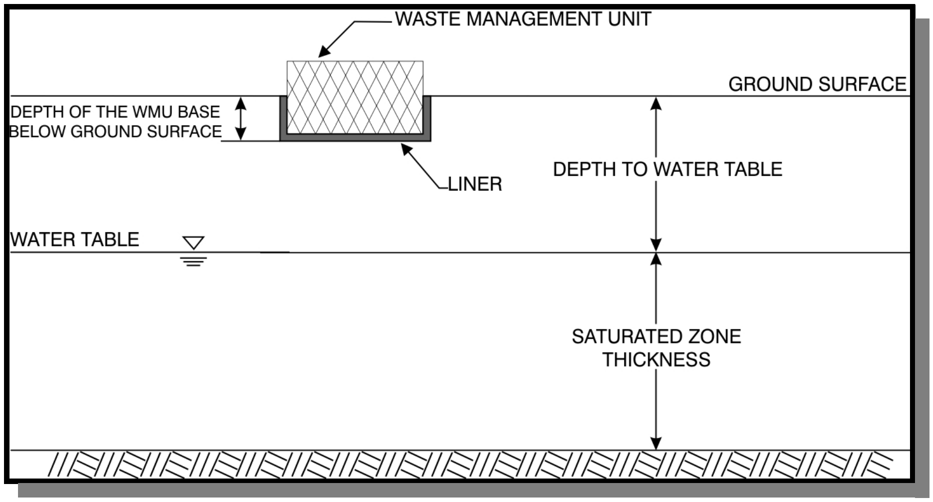

Figure 2.6 WMU with Base Elevation below Ground Surface.

Parameter Value or Distribution of Values

Data for this parameter were not included in the EPA's 1986 *Industrial Subtitle D Survey.* Unless site-specific data are available, users should set this parameter to zero, which is equivalent to assuming the base of the unit lies on the ground surface.

Data Sources

No nationwide distribution of values is currently available. For LF modeling analyses, this parameter value is typically set to zero, unless site-specific data are available.

Use In EPACMTP

If a non-zero value is entered for this input, then the thickness of the vadose zone beneath the LF is adjusted accordingly. In this case, EPACMTP will also verify that the entered value, in combination with the depth to the water table, and magnitude of the unit's infiltration rate, does not lead to a physically infeasible condition (e.g.,the LF base is not in contact with a static water table or an infiltration-induced water table mound) in accordance with the infiltration screening methodology presented in Section 2.2.5 of the *EPACMTP Technical Background Document* (EPA, 2003a).

2.3.4 Waste Fraction (F_h)

Definition

The waste fraction is defined as the fraction of the LF volume occupied by the modeled waste at LF closure.

Parameter Value or Distribution of Values

By default, this parameter is defined as a uniform distribution with lower and upper bounds of 0.036 to 1.0, respectively. However, if warranted by site-specific conditions or other assumptions, this parameter can also be set to 1.0 (the most protective case – equivalent to a monofill scenario), another constant value, or another distribution of values.

Data Sources

The default lower bound of 0.036 (which ensures that the modeled waste unit will always contain a minimum amount of the waste of concern), was obtained from an analysis of waste composition in municipal LFs (Schanz and Salhotra, 1992). The upper bound is the maximum value that is physically possible (the waste in the LF is composed completely of the waste of concern).

Note that an input value for this parameter is required for the LF scenario only.

Use In EPACMTP

EPACMTP uses the waste fraction to calculate the contaminant mass within the LF; the contaminant mass is an important input for the LF depleting source option (see Section 2.2.1.3.3 of the *EPACMTP Technical Background Document*; U.S. EPA, 2003a).

2.3.5 Waste Volume (PWS)

Definition

The waste volume is defined as the volume of the waste of interest (at LF closure) contributed to the Subtitle D LF.

Parameter Value or Distribution of Values

The waste volume is an input parameter that depends on the EPACMTP application. For nationwide risk assessments, EPA has typically assumed a default uniform distribution, where the waste volume is entered as a fraction of the entire landfill volume (see Waste Fraction in Section 2.3.4). If the landfill volume and the waste volume are treated as random parameters, specifying the waste volume in terms of a waste fraction ensures that the modeled waste volume can never exceed the modeled landfill volume.

For site-specific applications of EPACMTP, the waste volume that is entered as an EPACMTP input parameter can be calculated by multiplying the annual waste volume by the number of years of landfill operation. If the annual waste amount is given as a mass value (e.g., tons/year), it should be divided by the waste density in order to yield the value as a volume. The user should ensure that the modeled waste volume does not exceed the landfill volume.

Data Sources

Data sources depend on the EPACMTP application and are typically provided by waste generation data. For nationwide LF modeling analyses, this parameter is typically specified in terms of a waste fraction.

Use In EPACMTP

EPACMTP uses the waste volume to calculate the contaminant mass within the LF; the contaminant mass is an important parameter for the LF depleting source option (see Section 2.2.1.3.3 of the *EPACMTP Technical Background Document*; U.S. EPA, 2003a).

2.3.6 Leaching Duration (t_p)

Definition

The leaching duration is defined as the period of time that leachate is released from the WMU.

Parameter Value or Distribution of Values

By default, this parameter is set as a “derived” parameter to be calculated internally by EPACMTP as a function of the total amount of contaminant that is initially present in the landfill, and the rate of removal through the leaching process. Alternatively, the user may set this parameter to a specific constant value or a distribution of values.

Data Sources

No nationwide distribution of values is currently available. For LF modeling analyses, this parameter is typically set to be internally derived by EPACMTP.

Use In EPACMTP

If the leaching duration is set to a user-provided value or distribution, EPACMTP will model the LF using a pulse source (leaching at a constant concentration over a finite, pre-defined time period).

More commonly, the LF is modeled as a permanent waste management unit; in this case, the EPACMTP model assumes that leaching continues until the waste is depleted. To model this depleting source scenario, this input parameter should be specified as internally derived by EPACMTP. For a detailed discussion of how the LF source depletion rate is calculated, see Section 2.2.1.3.3 of the *EPACMTP Technical Background Document* (U.S. EPA, 2003a).

2.4 SURFACE IMPOUNDMENT (SI)

This section discusses the individual WMU-related parameters required to perform a SI analysis using EPACMTP. Most applications of EPACMTP are conducted on a national or regional basis for regulatory development purposes, in which case, most of the following SI input parameters would be described using the default probability. Distributions are discussed in the following sections. However, EPACMTP can also be used in a location- or waste-specific mode; in this case, each of the following SI input parameters could be assigned a site-specific constant value or a site-specific distribution of values. These site-specific data need to be gathered by the user prior to performing the EPACMTP modeling analysis.

The source-specific inputs for the SI scenario include parameters to determine the unit dimensions, ponding depth, and leaching duration. Together with the infiltration and recharge rates and the leachate concentration, these parameters are used to determine how much contaminant mass enters the subsurface and over what time period.

The source-specific parameters for the SI scenario are individually described in the following sections, and Figure 2.7 illustrates a compartmentalized SI as implemented in the EPACMTP model. Shown in the figure are, in descending order: the liquid compartment, the sediment compartment (with loose and consolidated sediments), and the vadose zone (with clogged and unaffected native materials).

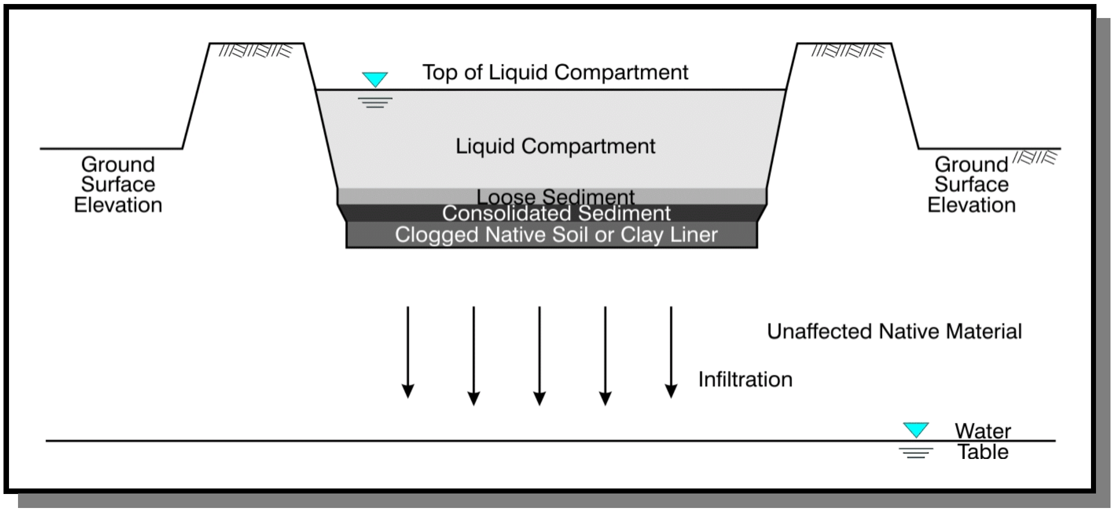

Figure 2.7 Schematic Cross-Section View of SI Unit.

2.4.1 Surface Impoundment Area (A_w)

Definition

The SI area is defined as the footprint of the impoundment. In EPACMTP, the impoundment is assumed to be rectangular. By default the unit is assumed to be square, i.e., to have equal length and width which are each calculated as the square root of the area.

Parameter Value or Distribution of Values

The entire distribution is presented in Appendix D. The cumulative frequency distribution of SI area is listed in Table 2.4. For a given percentile (%) frequency and value pair in this table, the percentile denotes the relative frequency or likelihood of parameter values in the entire distribution being less than or equal to the corresponding parameter value in the right-hand column.

Table 2.4 Cumulative Frequency Distribution of Surface Impoundment Area.

%	Area (m^2)
0	9.30E+00
10	1.74E+02
25	4.01E+02
50	1.77E+03
75	6.97E+03
80	8.90E+03
85	1.67E+04
90	2.83E+04
95	5.16E+04
100	4.86E+06

Data Sources

The data for SI area listed in Table 2.2 were obtained from EPA's *Surface Impoundment Study* (U.S. EPA, 2001a).

Use In EPACMTP

The SI area represents the total surface area over which infiltration and leachate enter the subsurface.

2.4.2 Surface Impoundment Ponding Depth (H_p)

Definition

The ponding depth is the average depth of the wastewater in the liquid compartment as shown in Figure 2.7; that is, this value does not include any sediment accumulated at the base of the unit.

Parameter Value or Distribution of Values

The entire distribution is presented in Appendix D. The cumulative frequency distribution of SI ponding depth is listed in Table 2.5. For a given percentile (%) frequency and value pair in this table, the percentile denotes the relative frequency or likelihood of parameter values in the entire distribution being less than or equal to the corresponding parameter value in the right-hand column.

Table 2.5 Cumulative Frequency Distribution of Surface Impoundment Ponding Depth.

%	SI Ponding Depth (m)
0	1.00E-02
10	4.60E-01
25	9.93E-01
50	1.81E+00
75	2.95E+00
80	3.44E+00
85	3.66E+00
90	4.24E+00
95	5.32E+00
100	1.82E+01

Data Sources

Data for the nationwide distribution of SI ponding depths was obtained from the *2001 Surface Impoundment Study* (EPA, 2001a).

Use In EPACMTP

The SI ponding depth is added to the unconsolidated sediment thickness (one-half of the total sediment thickness; see Section 2.4.4); this sum represents the hydraulic head that drives leakage of water from the SI. EPACMTP uses this parameter in order to calculate SI infiltration rates (see Section 4.3.4).

2.4.3 Surface Impoundment Total Thickness of Sediment (D_s)

Definition

The SI total thickness of sediment is the average thickness of accumulated sediment (sludge) deposits on the bottom of the impoundment. This layer of accumulated sediment is different from an engineered liner underneath the impoundment, but its presence will serve to restrict the leakage of water from an impoundment, especially in unlined units. The EPACMTP model assumes that the accumulated sediment consists of two equally thick layers, an upper unconsolidated layer and a lower consolidated layer (‘filter cake’) that has been compacted due to the weight of the sediment and wastewater above it, and, therefore, has a reduced porosity and permeability.

Parameter Value or Distribution of Values

A default value of 0.2m was adopted for the development of EPA's Industrial Waste Management Evaluation Model (U.S. EPA, 2003b). This agrees with the determination EPA made for values in the SI module of EPACMTP. Alternative data on this parameter are available, and can be extracted from EPA's *Surface Impoundment Survey*. However, these data have not currently been included in EPACMTP database of SI sites. See Section 2.2 for more information on the SI site database.

Data Sources

Data on SI sediment thicknesses were acquired from the nationwide *2001 Surface Impoundment Study* (EPA, 2001a).

Use In EPACMTP

The EPACMTP model uses the SI sediment thickness to calculate the rate of infiltration from unlined and single-lined SIs (see Section 4.2). The calculated infiltration rate is inversely related to the thickness of the sediment layer assuming constant ponding depth. A lower value for sediment thickness will result in a higher infiltration rate, and a greater rate of constituent loss from the impoundment. A detailed description of the EPACMTP SI infiltration module is provided in Section 2.2.2.3 of the *EPACMTP Technical Background Document* (U.S. EPA, 2003a).

2.4.4 Surface Impoundment Liner Thickness (D_{lin})

Definition

EPACMTP is able to account for infiltration through a single compacted clay liner beneath the SI. In the event that the SI is single-lined, the thickness of the liner must be provided. The liner thickness is defined as the average thickness of the single completed clay liner by which the SI is underlain. Additionally, the base of a lined SI is defined to be the interface between the liner and the native soils below. This definition permits EPACMTP to establish the elevation of the top of the liquid compartment relative to the unit base.

Parameter Value or Distribution of Values

As a default, EPA has assumed the SI clay liner thickness to be a constant 3 ft. or 0.916 m for nationwide or regional analyses. However, liner thickness can be represented by a distribution with the limitation that the minimum value be greater than zero. The clay liner is not allowed to be less than 0.1m to ensure numeric stability of the unsaturated zone flow simulation module.

Data Sources

The default liner thickness of 3 feet is based on typical design criteria for compacted clay liners underneath land disposal units (U.S. EPA, 2003b).

Use In EPACMTP

The EPACMTP model uses the SI liner thickness to calculate the rate of infiltration from the unit (see Section 4.2). The calculated infiltration rate is inversely related to the thickness of the liner assuming constant ponding depth. A detailed description of the EPACMTP SI infiltration module is provided in Section 2.2.2.3 of the *EPACMTP Technical Background Document* (U.S. EPA, 2003a).

2.4.5 Surface Impoundment Liner Conductivity (K_{lin})

Definition

The liner hydraulic conductivity is defined as the average saturated hydraulic conductivity of the clay liner mentioned in Section 2.4.4.

Parameter Value or Distribution of Values

By default, EPA has assumed the SI liner conductivity for compacted clay liners to be a constant 1.0 x 10^{-7}cm/s or 3.15 x 10^{-2} m/yr for nationwide and regional analyses. However, liner conductivity can be represented by any value or distribution of values with the limitation that the minimum liner conductivity must be greater than zero.

Data Sources

The default value of 1 x 10^{-7} cm/sec is based on typical design criteria for compacted clay liners beneath land disposal units and is the maximum recommended hydraulic conductivity for a compacted clay liner given in the EPA's *Guide for Industrial Waste Management* (U.S. EPA, 2003; EPA530-R-03-001).

Use In EPACMTP

The EPACMTP model uses the SI liner conductivity to calculate the rate of infiltration from the WMU (see Section 4.2). The calculated infiltration rate is directly related to the conductivity of the liner, assuming constant ponding depth. A detailed description of the EPACMTP SI infiltration module is provided in Section 2.2.2.3 of the *EPACMTP Technical Background Document* (U.S. EPA, 2003a).

2.4.6 Surface Impoundment Base Depth Below Grade (d_{BG})

Definition

This parameter represents the depth of the base of the unit below the surrounding ground surface, as schematically depicted in Figure 2.6.

Parameter Value or Distribution of Values

The default distribution is presented in Appendix D. The cumulative frequency distribution of SI depth below grade is summarized in Table 2.6. For a given percentile (%) frequency and value pair in this table, the percentile denotes the relative frequency or likelihood of parameter values in the entire distribution being less than or equal to the corresponding parameter value in the right-hand column.

Table 2.6 Cumulative Frequency Distribution of Surface Impoundment Depth Below Grade.

%	SI Depth Below Grade (m)
0	0.00E+00
10	0.00E+00
25	0.00E+00
50	1.22E+00
75	3.05E+00
80	3.58E+00
85	3.90E+00
90	4.57E+00
95	5.18E+00
100	3.35E+01

Data Sources

Data for this nationwide distribution for SI base depth below grade from the *2001 Surface Impoundment Study* (EPA, 2001a).

Use In EPACMTP

The depth of the base of the unit below the ground surface reduces the travel distance through the unsaturated zone before leachate constituents reach the water table. If a non-zero value is entered, EPACMTP will verify that the entered value, in combination with the depth to the water table, and magnitude of the unit's infiltration rate, does not lead to a physically infeasible condition (e.g., water table mound height above the ground surface or above the level of the waste liquid in an impoundment) in accordance with the infiltration screening methodology presented in Section 2.2.5 of the *EPACMTP Technical Background Document* (EPA, 2003a).

2.4.7 Surface Impoundment Leak Density (ρ_{leak})

Definition

EPACMTP can also account for infiltration through composite liners. The infiltration is assumed to result from defects (pinholes) in the geomembrane. The pinholes are assumed to have a circular shape and be uniform in size. The leak density is defined as the average number of circular pinholes per hectare.

Parameter Value or Distribution of Values

The cumulative frequency distribution of SI composite liner leak density is listed in Table 2.7.

Table 2.7 Cumulative Frequency Distribution of Leak Density for Composite-Lined SIs.

%	Leak density (No. Leaks/ha)
0	0
10	0
20	0
30	0
40	0.7
50	0.915
60	1.36
70	2.65
80	4.02
90	4.77
100	12.5

Data Sources

A nationwide, default distribution of leak densities (expressed as number of leaks per hectare) have been compiled from 26 leak density values reported in TetraTech (2001). The leak densities are based on liners installed with formal Construction Quality Assurance (CQA) programs.

Use In EPACMTP

The EPACMTP model uses composite liner leak density to calculate the rate of infiltration from composite-lined SIs (see Section 4.2). The calculated infiltration rate is directly related to the leak density of the liner. A lower value of leak density will result in a lower infiltration rate. A detailed description of the EPACMTP SI infiltration module is provided in Section 2.2.2.3 of the *EPACMTP Technical Background Document* (U.S. EPA, 2003a).

2.4.8 Distance to Nearest Surface Water Body (R_{∞})

Definition

The distance to the nearest permanent surface water body (that is, a river, pond or lake); note that this distance can be measured in any direction, not only in the downgradient direction.

Parameter Value or Distribution of Values

The data from the *Surface Impoundment Study* indicated a distribution of values with a range of 30 m to 5,000 m (up to 3.1 miles), and a median value of 360 m. The entire distribution is presented in Appendix D for this parameter. The cumulative frequency distribution is summarized in Table 2.8. For a given percentile (%) frequency and value pair in this table, the percentile denotes the relative frequency or likelihood of parameter values in the entire distribution being less than or equal to the corresponding parameter value in the right-hand column.

Table 2.8 Cumulative Frequency Distribution of Distance to Nearest Surface Water Body.

%	Distance to Nearest Surface Water Body (m)
0	0.00E+00
10	9.00E+01
25	2.40E+02
50	3.60E+02
75	8.00E+02
80	1.17E+03
85	1.60E+03
90	5.00E+03
95	5.00E+03
100	5.00E+03

Data Sources

Data from the EPA's *Surface Impoundment Study* (EPA, 2001a) were used to assign a distance value to each SI unit in the default EPACMTP database of WMU sites.

Use In EPACMTP

In the case of deep unlined impoundments, EPACMTP may calculate very high SI infiltration rates. EPACMTP checks against the occurrence of excessively high rates by calculating the estimated height of groundwater mounding underneath the WMU, and if necessary reduces the infiltration rate to ensure the predicted water table does not rise above the ground surface. The infiltration screening methodology is described in detail in Section 2.2.5 of the *EPACMTP Technical Background Document* (EPA, 2003a). This screening procedure requires as input the distance to the nearest point at which the water table elevation is kept at a fixed value. Operationally, this is taken to be the distance to the nearest surface water body.

2.4.9 Surface Impoundment Leaching Duration (t_p)

Definition

The time period during which leaching from the SI unit occurs. For SIs, the addition and removal of waste during the operational life period are assumed t be more or less balanced, without significant net accumulation of waste. Additionally, industrial SIs are, at the end of their operational life, typically dredged and backfilled. Even if simply abandoned, the waste in the impoundment will drain and/or evaporate relatively quickly. Consequently, in the finite source implementation for SIs, the duration of the leaching period is assumed to be the same as the operational life of the SI.

Parameter Value or Distribution of Values

In a typical SI modeling analysis, the SI is modeled as a temporary waste management unit. In this case, if site-specific data are not available, the user can make use of the distribution of SI operating life values summarized in Table 2.9 and presented in their entirety in Appendix D. For a given percentile (%) frequency and value pair in this table, the percentile denotes the relative frequency or likelihood of parameter values in the entire distribution being less than or equal to the corresponding parameter value in the right-hand column.

Table 2.9 Cumulative Frequency Distribution of Surface Impoundment Operating Life.

%	SI Operating Life (yr)
0	4.00E+00
10	1.50E+01
25	5.00E+01
50	5.00E+01
75	5.00E+01
80	5.00E+01
85	5.00E+01
90	5.00E+01
95	5.00E+01
100	9.50E+01

Data Sources

Data used to define this nationwide distribution of unit-specific operational lives for SIs were obtained from information in the *Surface Impoundment Study* on present age of the unit and the planned closing date (EPA, 2001a). If this information was missing, we assigned an operational life of 50 years.

Use In EPACMTP

EPACMTP assumes that the duration of the leaching period is equal to the unit's operational life; this leaching duration is then used to assign the length of the pulse-source boundary condition in the EPACMTP fate and transport simulation.

2.5 WASTE PILE (WP)

This section discusses the individual WMU-related parameters required to perform a WP analysis using EPACMTP. Most applications of EPACMTP are conducted on a national or regional basis for regulatory development purposes, in which case, most of the WP input parameters could be defined using a default probability distribution, described in the following sections. However, EPACMTP can also be used in a location- or waste-specific mode; in this case, each of the following WP input parameters could be assigned a site-specific constant value or a site-specific distribution of values. These site-specific data need to be gathered by the user prior to performing the EPACMTP modeling analysis.

The WMU-specific input parameters for the WP scenario include the area of the WP, the source leaching duration, and the depth of the base of the unit below grade. Together with the leachate concentration, infiltration rate, and recharge rate, these three parameters are used to determine how much contaminant mass enters the subsurface from the base of the WP over what time period. These WP input parameters are described in the following sections.

2.5.1 Waste Pile Area (A_w)

Definition

The WP area is defined as the footprint of the unit. In EPACMTP, the WP is modeled as being rectangular. By default, the WMU is assumed to be square, i.e., equal length and width. Thus, the length and width of the WP are each calculated as the square root of the area.

Parameter Value or Distribution of Values

The default nationwide distribution is presented in Appendix D. The cumulative frequency distribution of WP area is summarized in Table 2.10. For a given percentile (%) frequency and value pair in this table, the percentile denotes the relative frequency or likelihood of parameter values in the entire distribution being less than or equal to the corresponding parameter value in the right-hand column.

Table 2.10 Cumulative Frequency Distribution of Waste Pile Area.

%	Area (m^2)
0	5.06E+00
10	2.02E+01
25	2.02E+01
50	1.21E+02
75	1.21E+03
80	2.02E+03
85	3.72E+03
90	4.17E+03
95	1.21E+04
100	1.94E+06

Data Sources

The data for WP area listed in Table 2.2 were obtained from EPA's *1986 Subtitle D Survey* (U.S. EPA, 1986).

Use In EPACMTP

The WP area represents the total surface area over which infiltration and leachate enter the subsurface.

2.5.2 Waste Pile Leaching Duration (t_p)

Definition

The time period during which leaching from the WP unit occurs. WPs are a temporary management scenario in which the addition and removal of waste during the operational life period are assumed to be more or less balanced, without significant net accumulation of waste. Typically at the end of the active life of a WP, the waste material is either removed for land filling, or the WP is covered and left in place. If the waste is removed, there is no longer a source of potential contamination. If a WP is covered and left in place, it then becomes equivalent to a LF and should be regulated as a LF. Consequently, in the finite source implementation for WPs, the duration of the leaching period will, for practical purposes, be the same as the operational life of the WP.

Parameter Value or Distribution of Values

Since operational life is not one of the input parameters included in the EPA's *1986 Subtitle D Survey* (U.S. EPA, 1986), EPA has assumed a value of 20 years as a default value for WP operational life. Alternatively, a distribution of values could also be used.

Data Sources

The default value of 20 years is based on professional judgement of typical industrial waste management practices and consistency with EPA regulatory assessments of the active life of a unit.

Use In EPACMTP

EPACMTP assumes that the duration of the leaching period is equal to the unit's operational life; this leaching duration is then used to determine the total contaminant flux from the WP to the subsurface.

2.5.3 Waste Pile Base Depth below Grade (d_{BG})

Definition

This parameter represents the depth of the base of the unit below the ground surface, as schematically depicted in Figure 2.6.

Parameter Value or Distribution of Values

Unless site-specific data are available, users should set this parameter to the default value of zero, which is equivalent to assuming the base of the unit lies on the ground surface.

Data Sources

No survey data on this parameter are currently available. For WP modeling analyses, this parameter value is typically set to a default value of zero.

Use In EPACMTP

Greater depth of the unit below the ground surface reduces the travel distance through the unsaturated zone before leachate constituents reach ground water. If a non-zero value is entered, EPACMTP will verify that the entered value, in combination with the depth to the water table, and magnitude of the unit's infiltration rate, does not lead to a physically infeasible condition (e.g., the WP base is in contact with a static water table or an infiltration-induced watertable mound) in accordance with the infiltration screening methodology presented in Section 2.2.5 of the *EPACMTP Technical Background Document* (EPA, 2003a).

2.6 LAND APPLICATION UNIT (LAU)

This section discusses the individual WMU-related parameters required to perform an LAU analysis using EPACMTP. Many applications of EPACMTP are conducted on a national or regional basis for regulatory development purposes; in which case, most LAU input parameters would be defined using the default probability distributions described in the following sections. However, EPACMTP can also be used in a location-adjusted or waste-specific mode; in this case, each of the following LAU input parameters could be assigned a site-specific constant value or a site-specific distribution of values. These site-specific data need to be gathered by the user prior to performing the EPACMTP modeling analysis.

The WMU-specific input parameters for the LAU scenario include the area of the LAU and the leaching duration. Together with the leachate concentration, infiltration rate, and recharge rate, these two parameters are used to determine how much contaminant mass enters the subsurface from the base of LAU and over what time period. These LAU input parameters are described in the following sections.

2.6.1 Land Application Unit Area (A_w)

Definition

The LAU area is defined as the footprint of the unit. In EPACMTP, the LAU is modeled as being rectangular. By default, the WMU is assumed to be square, i.e., equal length and width. Thus, the length and width of the LAU are each calculated as the square root of the area.

Parameter Value or Distribution of Values

The default nationwide distribution is presented in Appendix D. The cumulative frequency distribution of LAU area is summarized in Table 2.11. For a given percentile (%) frequency and value pair in this table, the percentile denotes the relative frequency or likelihood of parameter values in the entire distribution being less than or equal to the corresponding parameter value in the right-hand column.

Table 2.11 Cumulative Frequency Distribution of Land Application Unit Area.

%	Area (m^2)
0	2.02E+01
10	4.05E+01
25	4.05E+03
50	4.05E+04
75	1.82E+05
80	2.43E+05
85	4.05E+05
90	6.48E+05
95	9.11E+05
100	8.09E+07

Data Sources

The data for LAU area summarized in Table 2.11 were obtained from EPA's *1986 Subtitle D Survey* (U.S. EPA, 1986).

Use In EPACMTP

The LAU area represents the total surface area over which infiltration and leachate enter the subsurface.

2.6.2 Land Application Unit Leaching Duration (t_p)

Definition

The time period during which leaching from the LAU occurs. Since LAUs are typically modeled as temporary waste management units using the pulse (or non-depleting) source scenario, this input is equivalent to the operational life. For LAUs, the addition and removal of waste (via leaching, biodegradation, etc.) during the operational life usually are assumed to be more or less balanced, without significant net accumulation of waste. Once waste application ceases at the end of the operational life of the LAU, the leachable waste is expected to be rapidly depleted. Consequently, if the LAU is modeled as a finite source, the duration of the leaching period will, in most cases be the same as the operational life of the LAU.

Parameter Value or Distribution of Values

Since operational life is not one of the input parameters included in the EPA's *1986 Subtitle D Survey* (U.S. EPA, 1986), EPA has assumed a value of 40 years as a default value for LAU operational life. Alternatively, a distribution of values could also be used.

Data Sources

The default value of 40 years is based on professional judgement of typical industrial waste management practices and consistency with existing EPA regulatory assessments on the active life of these units.

Use In EPACMTP

The leaching duration is used to determine the total contaminant flux from the LAU to the subsurface.